NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 4169

ATMOSPHERIC TEMPERATURE OBSERVATIONS TO 100,000 FEET FOR SEVERAL CLIMATOLOGICAL REGIONS

OF THE NORTHERN HEMISPHERE

By H. B. Tolefson

Langley Aeronautical Laboratory Langley Field, Va.

Washington

November 1957

TECHNIC TECHNIC

AFL 2011

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SUMMARY

Radiosonde measurements of upper-air temperatures taken over a 5-year period at nine stations in the northern hemisphere are summarized in order to provide information on the temperatures likely to be encountered during airplane and missile operations up to 100,000 feet. The results are in general agreement with those from previous investigations of upper-air temperatures and indicate that the mean temperatures from the tropopause to 100,000 feet tend to increase fairly regularly and rapidly for southern locations, whereas a smaller increase occurs for more northerly locations. The scatter in the temperatures about the mean generally decreased with increasing altitude from the tropopause to 100,000 feet. Little, if any, effect of location upon the temperature was apparent for altitudes above about 90,000 feet.

INTRODUCTION

Data on the atmospheric temperatures at different altitudes have a number of applications during both the design phases and the actual operations of high-speed airplanes and missiles. Measurements of the upper-air temperatures were summarized some time ago by the United States Weather Bureau in reference 1 in order to provide information on the frequency with which given temperatures might be expected at different altitudes and locations. These data covered radiosonde observations made over a 5-year period from locations within the continental United States and in adjoining areas and, because of limitations of the sounding equipment, were restricted to altitudes of about 50,000 feet.

With the more recent design of airplanes and missiles having much greater altitude and range capabilities, temperature data are now needed for higher altitudes and for other areas throughout the world. A summary of radiosonde temperature measurements was accordingly undertaken

by the National Advisory Committee for Aeronautics to extend the results in reference 1 to altitudes of about 100,000 feet and to several locations in the northern hemisphere. Although both the altitude and the area coverage of the results represented by this study are still limited, an effort was made through choice of station locations to obtain temperature data which could be considered representative of some of the wider climatological or geographical areas of the northern hemisphere.

Acknowledgment is made to the Office of Climatology of the United States Weather Bureau for their assistance in selecting the upper-air stations most suitable for the present study and to the National Weather Records Center for their services in processing the original observational data.

PRESENTATION OF DATA

Scope

Compilation of the available atmospheric temperature and pressure measurements to an altitude of 100,000 feet for a large portion of the earth would be a task of great magnitude. The compilation for continental United States, given in reference 1, and that for the North American continent, given in reference 2, suggest that the main temperature features, particularly at pressure levels corresponding to high altitudes, can be disclosed with significantly smaller effort by considering data for a few radiosonde stations selected to represent several broad climatological regions and geographic locations. Further, a survey of the available radiosonde data indicated that temperature and pressure measurements up to an altitude of about 100,000 feet and extending over a time interval of several years exist only for locations in the northern hemisphere. In view of these considerations, nine widely dispersed radiosonde stations in the northern hemisphere were selected to represent predominantly arctic, semitropical, maritime, and continental influences. Radiosonde observations covering a 5-year period were used for each station. The stations selected, their climatological regions, the time period covered by the observations, and the total number of radiosonde soundings from each station are listed in the following table:

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Station	Influences represented	Period of observation	No. of soundings
Thule, Greenland	Arctic	Jan. 1951 - Dec. 1955	1,785
Barrow, Alaska	Arctic	Jan. 1951 - Dec. 1955	1,816
San Juan, P. R.	Semitropical	Jan. 1951 - Dec. 1955	1,823
Ocean station vessel Echo (lat. 35° N., long. 48° W.)	Maritime	Jan. 1951 - Dec. 1955	1,751
Ocean station vessel Victor (lat. 34° N., long. 164° E.)	Maritime	Sept. 1951 - Aug. 1956	1,767
International Falls, Minn.	Continental	Jan. 1951 - Dec. 1955	1,793
El Paso, Tex.	Continental	Jan. 1951 - Dec. 1955	1,820
Itazuki (Fukuoka), Japan	Continental	Jan. 1951 - Dec. 1955	1,772
Wiesbaden, Germany	Continental	JanApr., June-Aug., OctNov., 1950 Jan., Mar., May, Sept., Dec., 1951 Feb., AprDec., 1952 Jan. 1953 - Dec. 1955	1,752

The data for the stations in the table were confined to the daily radiosonde observation taken near 2300 e.s.t. (0300 Z). Because of differences in longitude of the stations, some of the data represent nighttime observations while others represent daytime observations. Temperature differences resulting from these differences in local time of the soundings are not considered significant for the higher altitudes which are of particular interest in this study. References 3 and 4, for example, indicate that diurnal temperature variations at the higher altitudes amount only to about 0.5° C. It may also be noted that with the exception of the data for Wiesbaden, Germany, each set of soundings covered about the same continuous 5-year period.

Results

The results are summarized in table I in terms of the frequencies f and the cumulative probability distributions cpd of the temperatures t observed at given altitudes for each of the nine stations. For the different stations, separate distributions are given for each month of the combined 5-years' sample of data and for the total 5-years' sample. The temperature data given in the table were obtained at the standard reporting pressure levels of 850, 700, 500, 300, 200, 100, 50, 30, 20, and 10 millibars. For convenience, these pressure levels are expressed as the corresponding geometric altitudes in the standard aeronautical atmosphere specified in references 2 and 5.

Each entry in table I refers to a temperature observation within a class interval of 2°C. A frequency value for a temperature of 10°C, for example, indicates the number of observations between 10°C and 11.9°C, and a frequency value for a temperature of -10°C indicates the number of observations between -10°C and -8.1°C. The cumulative probability distributions indicate the percentage of observations for which the temperatures exceeded the specified values. It was considered that tabular presentation would place the data in the form most suitable for a variety of uses, such as determining seasonal variations at a given location, the mean, or the standard deviation of the temperatures about the mean at different altitudes.

It might be noted from table I that the number of observations obtained decreases rapidly with altitude, particularly for altitudes above 67,500 feet, because of limitations in the performance of balloon sounding equipment. For Wiesbaden, Germany, only three observations were obtained at altitudes above 67,500 feet in January and February because of interrupted weather services during these months over parts of the 5-year period selected for study. For completeness, however, all observations were tabulated, regardless of how few were available. In addition, all singularities noted during the tabulation of the data by the National Weather Records Center were checked against data reported by previous or following soundings.

It might be pointed out that for each altitude table I approximates a graph in which temperature is the ordinate, time is the abscissa, and the curves are formed by lines running through constant values of the cumulative probability distributions. Thus, the variations in the temperature with season, altitude, and location may be readily observed from the table.

DISCUSSION

Table I indicates large monthly and seasonal temperature variations at all altitudes for the northern locations as compared with somewhat smaller variations for the southern locations. A few examples of the extreme variations in the temperature during summer months (June, July, and August) and winter months (December, January, and February) at altitudes above the tropopause are summarized in the following table for stations representing arctic, semitropical, and maritime regions.

		Temperat	ure range, C	C, at altitu	de of	
Station	67,50	0 ft	78,50	X ft	87,00	0 ft
	Summer	Winter	Summer	Winter	Summer	Winter
Thule, Greenland $\begin{cases} t \\ (arctic) \end{cases}$	-40 to -50 10	-42 to -82 40	-38 to -50 12	-44 to -82 38	-36 to -48 12	
San Juan, P. R. {t (semitropical) {\Deltat}	-56 to -64 8	-60 to -80 20	-44 to -60 16	-50 to -70 20	-48 to -54	-46 to -64 18
Ocean station vessel Victor $\{t \\ (maritime) \}$	-54 to -64 10	-52 to -70 18	-46 to -58 12	-46 to -64 18	-44 to -54 10	-42 to -60 18

The primary indications of the preceding summary are the generally colder temperatures and the larger spread in the temperatures at all locations for the winter months than for the summer months. In similar investigations (ref. 6, for example) tendencies have been found for the temperatures at altitudes near 100,000 feet to be somewhat colder for northern locations than for more southerly locations. These latitude effects are not particularly apparent in the foregoing summary or in table I. The relatively few observations at 102,000 feet in the present summary, however, do not permit definite conclusions to be made in regard to such tendencies in the temperatures.

For a better illustration of the variations in temperature at the different altitudes, the mean temperature and the standard deviation of the temperatures about the mean are plotted against altitude in figure 1 for the 5-years' set of observations taken at Barrow, Alaska, ocean station vessel Victor, International Falls, Minnesota, and San Juan, Puerto Rico. The standard deviation σ is a useful measure of the scatter in the data about the mean and indicates the range that includes approximately 68 percent of the observations. The points in figure 1 are plotted slightly above or below the given altitudes for ease in distinguishing the average temperature and the values of σ . The variations in temperature with altitude for the standard atmosphere of references 2 and 5 are also shown by the curve in figure 1 for comparison with the observed data.

The much colder temperatures at tropopause levels and the wide departures from the temperatures for the standard atmosphere are evident for the southern locations from inspection of figure 1. Also, conditions in the stratosphere for the southern locations are characterized by a fairly large increase in the temperatures with altitude, while a small increase occurs for the more northerly locations. The mean temperatures for the high and low latitudes appear to converge at about 90,000 feet. Similar variations in the mean temperature with altitude above the tropopause for different latitudes are discussed in references 6 and 7.

The values of σ in figure 1 point out the very small variations in troposphere temperatures throughout the year for semitropical locations and the much larger variations for high-latitude stations. Above the tropopause, the temperature spreads generally decrease as altitude increases to 102,000 feet. The comparatively small amount of data obtained at the highest levels does not permit complete confidence to be placed in the values of σ at these altitudes, but in general it appears that the scatter in the temperatures about the mean values is represented by a value for σ of 10°C or more at low altitudes and less than 5°C at the higher altitudes.

CONCLUDING REMARKS

The preceding summary of the upper-air temperature measurements taken at nine radiosonde stations over a 5-year period provides basic temperature statistics for use in airplane and missile design studies. The stations were selected to represent given geographic or climatological influences, and the expected wide departures in the temperatures from those specified for standard atmospheric conditions were noted. The scatter in the temperatures at different altitudes agrees with the results from other investigations, and in terms of the standard deviations of the temperatures about the mean, frequently exceed 10°C in the troposphere and are less than 5°C for altitudes from the tropopause to 100,000 feet.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., August 23, 1957.

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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES

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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

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30,000	-38 -40 -42 -46 -46 -50 -52 -56 -58 -66 -68	13	1 2 4 11 18 40 62 79 88 97 99	23 37 19 19 29 22 2 1	4 6 11 25 39 53 74 90 96	1 10 7 18 30 32 23 22 9	1 7 12 24 43 64 79 94 99	1 2 6 12 23 25 39 24 14 3	1 2 6 14 30 46 73 89 98 100	2 2 10 14 21 36 41 21 6	1 3 9 18 32 56 82 96 100	1 2 8 14 26 34 33 14 6	1 2 8 18 37 62 86 96	3 2 12 21 34 40 31 8 2	2 3 11 25 47 73 94 100	2 5 16 29 40 28 17 6	1 5 18 36 64 83 95 95	2 2 8 26 37 42 15 42	1 3 9 28 54 85 96 99 100	12 19 17 24 35 30 1	3 11 20 31 37 53 77 97	1 3 17 33 37 29 18	1 3 15 38 64 84 97 100	1 4 5 19 30 33 28 28 4 2	1 3 7 19 38 60 78 96 99	3 5 21 54 100 164 196 240 273 256 207 150 69 10	1 2 5 10 20 31 45 60 75 87 95 100 100	-38 -42 -44 -48 -52 -55 -66 -68 -68
38,500	-40 -42 -44 -46 -50 -52 -56 -58 -60 -64 -66 -70 -72	75113	2 9 14 29 44 62 79 89 93 94 96 100	8 4 8 15 22 15 23 18 11 2 1 2 1	6 9 15 27 44 55 73 87 95 97 98 99	2 3 9 16 24 30 16 24 9 6 32 2	1 3 5 11 22 38 58 69 85 91 95	5 10 27 40 22 21 9 3 1 3 2	4 10 29 57 72 87 95 96 98 99	3 12 28 54 14 7 4 4 1	29 64 80 89 94 97	1 5 25 27 35 17 10 5 8 2	1 4 23 43 68 81 88 92 98 100	5 17 20 30 20 21 11 7 5 6 4	3 15 28 48 615 52 87 90 93 97 100	2 8 23 22 34 20 12 5 8 7 2	1 7 22 37 61 74 82 86 91 96 97 100	3 15 26 29 30 15 11 . 5 4	2 13 32 53 74 85 93 96 99 100	2 5 7 19 27 24 16 6 2 4 6 3 1	15 10 24 43 672 84 88 92 96 99 99	6 18 39 28 26 13 2 3 2	4 17 45 65 84 93 95 96 99 100	138522 22210798441	138549 24918284796884790	10 44 99 164 250 261 275 203 173 98 49 29 24 21 12	76 86	-40 -42 -44 -46 -50 -52 -54 -58 -62 -64 -66 -70 -72
53,000	-38 -40 -44 -44 -46 -52 -54 -58 -58 -62 -66 -70 -72	2 7 24 18 19 12 11 10 5 1	3 4 10 31 47 64 74 84 92 97	1 1 3 6 8 12 16 18 120 2 2 2 1	95 97 99	1 2 7 6 8 9 16 27 28 11 7 2 1 5	96	4 13 26 30 32 20 10	3 13 32 54 78 93 100	7 21 52 56 12	9Z	11 67 40 12 3	8 59 98 100	1 39 57 38 12 1	1 27 66 91 99 100	12 9 4 5 1 3 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	9 51 83 98 100	11 30 63 26 3	8 31 78 9E 100	4 4 12 30 111 7 1 1 1 1 1	47 18 45 631 91 97 99 100	1 1 4 18 22 35 14 9 10 1	1 25 18 35 62 745 92 99 100	11453213116274211	1 25 12 33 51 62 77 87 97 98 90	2 3 16 26 26 306 21 35 45 21 35 45 21 17 52 11	1 74 44 63 77 85 95 97 98 100 100 100	-38 -40 -42 -44 -48 -50 -52 -54 -58 -64 -64 -72

TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

87,500 -36 -38 -40 -42 -44 -46 -50 -52 -54 -50 -60 -62 -64 -68 -68 -68 -68 -68 -68 -68 -68 -68 -68	1 1 2 1 1 1	56 13 295 5776 877100	13 22 1 2	100	11 2111612	99 100 6 13 25 31 38 44 81 100	3 7 14 6 8 6	3 24 44 46 97 100	3 277 403 316 4 6 111 64 149	24 57 100 24 97 100	3 44 50	cpd % 42 87 99 100 2 12 60 97 98 100	8 73 44 8	61 61 94 100	16 38 59 16 2 4 10 29 30 31 2	12 41 86 99 100	5 43 425 8 1	5 5 8 29 70 92 100	1 11 10 15 8 6	2 4 42 42 49 84 100	1 3 2 6 15 12 7 7	1669 1736464 67467 8797	23135897113211	4 10 13 19 29 46 57 97 81 90 94 98 100 14 43	1 3 4 24 145 162 173 123 131 131 173 173 173 173 173 173 173 17	17 35 50 473 87 97 100 100 100 100 27 58	-36 -38 -42 -44 -46 -50 -54 -56 -66 -70 -42 -44 -48
-38	10 4 14 12 7 3 1 2 2 1 1 1 2 1 1	5 6 13 35 57 76 87 92 100	2141987411 13 22 1 2 1	6 11 125 28 422 64 83 97 100 9 36 55 73 82	924255846735 21 II 2111612	158 1315 22239 44 511739 96 99 100 613 253138 44188	3 7 14 6 8 6	3 24 44 46 84 97 100 5 18 43 54 68 79 68	3 27 40 33 16 4	2 24 57 100 12 35 47 76 94	3 44 50 13 1	3 42 87 99 100	8 73 44 8 1 18 37 17	6 61 94 100	16 38 59 16 2 4 10 29 30 31 2	12 41 86 9100 5 16 48 82 96	4 23 46 25 8 1	5 8 29 70 92 99	1 11 10 15 8 6	2 4 4 42 49 84 95	3 2 6 13 12 7 7	1 6 9 17 364 674 87 97	3135897113211 1 12 1	4 10 13 19 29 46 57 98 81 90 94 98 100 14 43	34 445 182 173 110 737 427 18 83 11 30 84 848	11 337 355 300 413 979 979 100 100 1100	
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-8 7 -10 4 -12 1 -14 -15	2	14 63 90 98 99	1 26 52 48 10 1	19 57 91 99 99	5 31 77 31 7	3 24 74 94 99 100	2 48 49 41 9	1 34 66 94 100	2 32 74 38 5	1 23 72 97 100	29 90 30	20 80 100	1 34 89 30 1	1 23 80 99 100	9 54 79 9	6 42 94 100	5 47 79 16 2	35 85 99 100	1 4 57 71 20	1 3 41 87 100	10 51 54 31 3	7 41 77 98 100	1 50 62 33 7	1 33 74 95 100	1 40 481 850 369 56 5	2 29 76 97 100 100	-2 -4 -6 -10 -12 -14 -16
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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

4.14	Γ.		90.	1	eb.	М	arch	A	pril	В	Lay]]	une		шу		λαg.		ept.		Oct.	1	TOY.	T	Dec.	To	(a)	Γ.
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53,000	-68 -70 -72 -74 -76 -80 -82 -84	2 10 25 46 35 14	2 9 28 63 89 100	7 22 60 28 12	5 23 69 91 100	7 38 55 32 6	5 32 72 95 99 100	5 14 41 45 13 5	4 15 49 85 96 100	7 14 37 35 15 4	6 19 52 83 96 100	10 24 44 19 8 5 2	9 30 69 86 93 97 99	1 14 40 52 24 2	1 11 41 81 99	5 26 62 35 8 1	23 68 93 99 100	3 8 26 26 43 12 1	3 9 31 53 89 99 100	1 6 25 35 30 22 4 2	1 6 25 53 76 94 98	9 25 53 33 6 1	7 27 68 94 98 99	3 5 25 47 31 28	2 6 24 58 80 100	4 38 139 275 369 401 216 83 5	30 30 54 80 94 100 100	-68 -70 -72 -74 -76 -78 -80 -82 -84 -86
67,500	-54 -56 -62 -64 -66 -70 -74 -74 -78	3 5 16 18 25 5 1	4 8 14 35 58 90 96 97 99	2 11 23 17 16 9	2 5 18 46 66 86 96	1 2 3 15 28 27 18 7	2 4 7 21 48 74 91 98	2 9 11 25 23 14 1	2 13 26 55 81 98 99	1 4 19 16 16 12 8	1 3 8 33 59 74 90 100	2 5 18 30 24	3 9 32 70 100	2 6 32 39 15	2 9 43 84 100	11 35 44 19	10 42 83 100	2 16 32 19 7	3 24 66 91 100	2 6 32 30 11 4	2 9 47 82 95 100	5 23 26 23 13	6 31 60 86 100	2 8 18 27 18 7 2	2 12 33 66 87 95 98 100	2 5 33 149 243 229 170 119 67 24 8	18 41 63 79 90 97 99 100 100	-54 -56 -58 -60 -62 -64 -66 -70 -72 -74 -76
78,500	-44 -48 -50 -54 -58 -62 -64 -70		17 44 83 96 98	1 1 4 9 13 13 5 2	2 4 13 31 58 85 96 100	1 8 7 24 19 10 3	1 12 22 55 81 95 99	3 1 11 23 9 3	6 8 30 76 94 100	2 5 13 20	4 15 42 83 100	1 1 3 2 15 18 5 1	2 5 11 16 50 91 98 100	6 15 25 4	12 42 92 100	1 7 17 22 13 2	2 13 40 76 97 100	2 1 6 18 11 1	5 8 23 69 97	3 14 24 11 3	6 31 75 95 100	1 2 4 16 12 12 9 2	2 5 12 40 60 81 97	1 12 16 14 10 2	2 23 52 77 95 98 100	1 1 15 36 119 209 142 78 21 5	1 3 9 28 61 83 96 99 100	-44 -46 -48 -50 -52 -54 -56 -58 -60 -62 -70
87,000	-468 -56824 -56824 -4468042 -6754	2 6 4 5 6	8 33 50 71 96	3 4 7 4 2	13 25 42 71 88 96 100	1 4 13 5 3 2 7	3 17 60 77 87 93 100	64451	30 50 70 95 100	1 3 7 1	8 31 85 92 100	3 6 1 1	27 82 91 100	1 3 5 8 2	5 21 47 90 100	2 6 7 2	12 47 88 100	1 1 4 7 1	7 13 20 47 99 100	1 3 10 11	4 16 56 100	5 17 3 3	18 79 89 100	1 53422	55 53 77 88 100	1 4 31 72 56 50 15 12 1	2 15 44 68 88 94 99 100	-44 -46 -50 -52 -54 -56 -58 -62
102,000	-42 -44 -46 -48 -50 -54 -62	1 1 1	33 67 100			1 2 3 1	17 33 83 100		50 100					1	100			1	100							2 1 4 3 1 1	15 23 54 77 85 92 100	-42 -44 -46 -48 -50 -54 -62
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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

Alt.,	t,	J	an.	F	eb.	M	arch	A	pril	N	lay	J	nue	J	uly		ug.	8	ept.	C	et.	1 2	lov.	<u></u> i	Dec.	Tot	al	Γ.
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18,000	-6 -8 -10 -12 -14 -16 -18 -20 -22 -24 -26 -30	8 21 29 41 18 19 5	6 20 41 70 82 96 99	2 13 38 24 32 7 11 5 3	2 11 39 56 80 85 93 96 99	2 12 29 28 28 19 8 6 3	1 3 12 33 53 73 87 93 97	3 14 28 37 25 24 8 2	2 12 32 57 75 92 97 99	7 49 47 32 3 3 4	38 71 93 95 97 99	4 57 61 21 2	3 42 84 99 100	1 24 54 60 12 2	1 16 52 91 99 100	16 40 58 27 1	11 39 80 99 100	13 39 47 37 4	9 37 70 96 100	27 26 38 23 9 2 1	3 24 43 72 89 96 98 99	1 11 43 32 25 13 4	1 9 43 67 87 97 100	6 12 22 44 26 14 7 5	4 13 29 61 80 91 96 99	34 135 271 353 238 247 162 125 65 31 13 7 4	100	-10 -12 -14 -16 -20 -22 -24 -28
30,000	-32 -34 -36 -40 -42 -44 -46 -52 -54	1 11 25 25 43 19 10 4	1 9 27 45 76 90 97 100	59 26 329 17 32 1	4 18 37 61 83 96 98	2 3 6 12 7 32 5 2 2 5 1	2 4 8 17 37 61 79 96 99	1 6 22 18 32 28 20 10	1 5 21 34 57 78 92 99	5 13 41 41 23 10 1	4 13 44 75 92 99	2 18 98 48 10 3 1	1 14 56 90 97 99 100	12 30 56 39 8 2	8 29 67 93 99 100	2 21 60 45 14	1 16 59 90 100	3 27 41 43 17 7	2 22 51 83 95 100	2 14 24 37 26 18 7	2 31 60 80 94 99	3 12 35 40 19 12 3	2 12 40 73 88 98 100	11 16 29 28 26 12 14	\$ 20 41 61 80 89 99	7 76 184 285 280 227 192 185 109 73 13 4	16 34	-32 -34 -36 -40 -42 -44 -48 -52 -52 -54
38,500	-46 -48 -50 -52 -54 -56 -60 -62 -64 -66 -70	2 6 8 6 9 10 15 24 18 17 6	2 3 8 14 19 26 34 46 66 80 94 98 100	654015 1911 151 157	5 9 12 20 32 47 56 68 82 94	1 3 4 5 6 11 13 8 19 25 19 8	1 3 7 11 15 24 35 41 57 77 92 98 100	5 1 6 4 25 33 16 4	5 6 11 14 33 59 84 96	4 1 3 18 28 50 18 3	3 4 6 9 23 45 84 98	1 7 37 68 21	1 6 33 84 99 100	7 10 37 47 35 5	1 6 13 39 72 97 100	2 10 23 51 46 6	1 9 25 62 95 99 100	1 10 33 36 25 10	1 8 32 74 92 99 100	7 30 38 26 14	1 3 8 33 64 85 97 100	1 3 2 9 17 40 25 17 5 2	1 5 12 26 60 80 94 98 100	3 2 4 10 11 15 19 31 26 9	2 4 7 14 23 34 49 72 92 99	5 18 25 49 88 222 320 306 248 161 84 29	23 6 12 26 47 66 82 98 100 100	-64 -66 -68
53,000	-56 -58 -60 -62 -64 -66 -72 -72 -74 -76	6 3 21 24 20 10 6 5	4 10 13 34 57 77 87 93 98	15 12 16 12 15 11 15 11 13	1 6 22 36 53 67 83 96 99	4 7 14 19 15 14 10 5 2	4 12 28 49 66 81 92 98 100	1 12 21 25 24 12 6	1 2 14 34 58 82 93 99	7 7 23 28 23 11 4	7 14 36 43 85 95 99	3 15 26 30 31 10 3 2	3 15 37 62 88 96 98	2 23 49 35 16 5	2 19 57 84 96 100	8 18 34 36 18 1	7 23 52 84 99	1 2 15 25 35 26 7 3	1 3 16 38 68 91 97 100	4 5 12 18 15 16 14 8	4 10 22 41 57 74 88 97	2 10 13 23 11 18 3 4 1	2 14 29 56 69 93 98 99	1 6 14 13 23 16 13 8 5	1 7 21 34 58 74 87 95	6 30 75 157 245 270 222 127 65 31 14 4	22 41 63 81 91 96 99 100 100	-62 -64 -68 -70 -72 -74 -78
67,500	-502 -54 -56 -58 -62 -64 -66 -68 -70	7	15 27 52 73 89 96 100	1 6 6 12 8	3 29 45 76 97	3 4 14 7 9 2 2 1	7 17 50 67 88 93 98	1 4 15 15 10 2	2 10 18 47 77 96 100	1 16 35 16 2 1	7 28 75 96 99 100	3 23 40 17 2	31 78 98 100	2 31 47 11 2	2 36 86 98 100	1 2 32 43 11 1	1 3 39 87 99 100	31	9 54 90 99 100	3 15 16 19 10	5 28 53 83 98 100	1 2 6 14 12 8 6	2 6 16 42 64 78 89 100	3 4 8 19 11 9 3 2	12 25 58 76 92 97	1 2 20 122 259 165 100 63 32 17	18 51 72 85 93	-50 -52 -54 -56 -62 -62 -64 -68 -70

TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

	Π.	J	an.	F	eb.	Ms	ırch	A	prii	1	[Ry	J	me	J	ıly	A	ug.	8	pt.	0	ct.	N	OV.	D	ec.	Tot	eI.	Γ.
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102,000	-44 -46 -52 -54		100			1	100			1	100	1 2	33 100			1	100	1	50 100							1 4 2 1	11 56 78 89 100	-44 -46 -52 -54 -56
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18,000	-20 -20 -20 -12 -12 -12 -12 -12 -12 -20 -22 -22 -22 -30 -32 -34	1 4 3 16 35 19 22 12 6 3 1 1	1 4 6 17 41 55 68 83 92 96 98	1 75 322 27 11 9 6 3 1	16 16 39 54 73 87 93 97 100	1 4 19 43 47 20 5 4	1 4 17 47 79 93 91 99 100	1 13 25 44 38 13 7 7 2 3	1 10 26 56 82 91 95 97 99 100	1 3 15 50 34 32 8 2	1 3 13 48 71 93 99 100	III 47 50 27 8 2	8 40 74 98 98 99 100	48 66 26 8	3 34 78 95 100	7 52 57 53 2	5 39 77 99 100	13 13 13 13 13 13 13 13 13 13 13 13 13 1	11 56 93 97 99	7 30 44 43 4 1	5 25 67 99 99 99	2 9 45 32 I 1 2 9 3 4 1	1 8 38 60 74 88 95 97 99 100	1 12 22 29 25 20 10 8 4	1 5 13 27 47 47 85 92 97 100	2 47 262 4061 2005 2053 90 54 37 22 9	96 98	-10 -12 -14 -14 -18 -20 -24 -26 -26 -30

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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

Alt.,	t,		an.]	eb.	M	arch	A	pril	У	iny	3	une	_	uly	_A	ug.	S	ept.	0	ct.	N	OV.		ec.	To	al	t,
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30,000	-280 -392 -342 -342 -342 -446 -446 -446 -556	16 17 18 22 14 12 15 7	16 29 42 58 68 77 88 93 96 99	14 14 11 13 11 22 20 13 15 7 6 3	14 21 38 54 68 77 88 93	3 5 13 22 32 38 23 6	2 6 15 30 53 80 96 100	5 19 29 36 32 13 7	4 17 37 62 84 93 98	14 36 36 41 9 5 2	10 35 60 89 95 99 100	12 50 41 25 9 4 2	8 43 72 90 96 99 100	42 62 24 12 1	3 31 74 90 98 99 100	1 8 30 58 34 9 5	1 6 27 67 90 97	2 20 48 34 7 2	2 20 62 92 98 100	6 19 40 43 34 3 2 1	4 17 44 73 96 98 99 100	1 14 35 40 16 10 32 1	1 135 637 77 88 95 97 99	1 1 6 8 2 2 2 2 2 3 3 8 7 7 8	1 1 6 11 29 47 63 79 85 90 94	1 3 497 227 382 317 230 158 124 92 61 29 11 3	81 94 97 99 100 100	-42 -44 -48 -50 -52 -54
38,500	~446 ~480 ~524 ~524 ~536 ~546 ~566 ~668	4 8 20 42 20 17 9	2 5 11 27 58 74 86 93 96	2 1 8 10 41 29 21 16 4 2	46 67 82 94 97	67 15 20 18 19 14 10 18 7	4 10 21 36 49 63 73 81 94 99	1 1 11 9 13 22 22 37 16	1 10 17 26 42 58 84 96 99	8 22 49 37 16 8	6 21 56 83 94 100	1 4 29 65 27 9 3	1 25 72 91 98 100	31 66 36 9 1	3 24 69 93 99 100	5 31 64 32 11	25 70 9 <u>2</u> 100	2 9 17 49 34 3	2 10 25 68 97 100	1 11 28 48 42 11	1 1 9 28 61 90 97 99 100	3 1 12 43 46 17 12 7	2 3 11 42 75 87 95	1 4 6 14 9 41 2 9 5 1 2	1 8 19 40 71 87 98 98 99	7 10 33 54 183 306 451 312 140 86 47 12	6 18 36 64 83	-44 -48 -50 -52 -56 -58 -62 -64 -68
58,000	-546-6-6-7-7-7-6-6-8-2-8-2	2 6 4 16 14 18 24 9 4	2 4 6 12 15 29 42 50 66 87 95 98	16 16 18 13 17 20 9	48 59 74 91 98	1 2 10 14 23 21 24 19 7	1 3 11 22 41 58 78 93 99	2 7 11 27 20 29 15 11 2	2 8 17 40 56 76 88 98 99	4 8 33 30 19 19 12	3 10 36 60 75 90 99	1 1 2 20 35 28 12 4	1 2 20 26 34 63 85 95 98	4 19 26 44 21 17 3	3 17 37 69 85 98 100	2 15 29 30 25 14 11 2	2 13 36 59 7.8 89 98 98	25 55 164 157 62 1	2 7 12 27 60 75 91 97 99	2 7 5 12 30 34 32 6 2	2 7 11 20 43 69 94 99	1 5 7 11 16 18 22 18	13 13 19 28 42 57 75 91	5 5 15 7 15 14 27 16 6 3	49 22 28 41 54 77 97 97	2 3 9 42 96 187 221 230 213 135 76 25	1 4 11 24 39 53 69 83 93 98	-54 -56 -60 -62 -64 -64 -68 -70 -72 -74 -78 -80 -82
67,500	-52 -54 -56 -58 -60 -62 -64 -66 -68	10 15 15 14 13	1 2 7 19 37 55 72 88 99	3 5 9 20 9 29 29	3 9 20 43 53 86 97 99	4 14 19 36 5 10 3	4 20 40 79 85 96 99	1 1 5 17 28 26 12 3	26 55 83 96 99	1 8 33 46 22 2	10 39 79 98 100	2 14 49 30 8 1	2 15 63 91 99 100	4 25 56 31 2	3 25 72 98 100	4 18 47 40 4	19 61 96 99 100	1 6 27 41 15	37 82 99 100	2 9 24 40 23 10 4	2 10 31 67 88 96	2 1 21 26 24 22 6	2 3 24 49 73 94	3 7 8 19 23 12 6	13 23 46 75 98 100	3 19 96 279 322 222 135 79 31	10 33 60 79 90 97	-52 -54 -56 -58 -60 -62 -64 -66 -68
78,500	-46 -48 -52 -54 -56 -62 -64	2 5 8 11 11	4 8 17 32 53 74 87 94	8 10 14 13 2 4	15 33 58 82 66 93	2 4 18 19 16 9	3 9 35 63 87 100	1 6 10 23 24 8	1 10 24 56 89 100	1 12 34 26 12 1	1 6 19 57 86 99 100	3 10 31 22 4	18 62 93 99 100	1 20 36 26 4	1 8 28 67 96 100	1 4 8 36 44 4	13 51 96 100	.1 8 17 31 11	1 13 38 83 99 100	1 5 13 17 23 14 4	1 8 25 47 77 95	1 3 18 9 22 10 5	1 3 7 39 46 77 91 99	1 1 3 11 19 8 4 2	2 11 16 36 71 86 93 96	22 78 200 254 154 95 36 15	1 3 12 35 64 82 73 77 99	-46 -48 -50 -52 -54 -56 -58 -60 -62 -64
87,000	-42 -46 -46 -50 -52 -56 -58 -60	3 6 4 2 1	5 11 26 58 79 90 95		13 31 50 63 81 94	1 3 8 4 6	5 18 55 73 100	122562	6 17 28 56 89 100	1 3 13 4 1	4 17 74 91 96	3 10 5 3 1	14 59 82 96 100	2 9 11 9 1	6 33 67 94 97 100	1 4 16 15 3 2	2 12 51 88 95 100	1 5 10 7	4 8 28 68 96	1 2 4 11 6	12 28 72 96 100	2 7 4 4 2	11 47 68 90 100	1215436	4 13 17 38 54 67 92	1 9 26 69 67 58 33 14 8	80	-42 -46 -46 -52 -54 -54 -58 -60
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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

Alt.,	t,	J	an.	F	eb.	M	irch	A	pril	1	(ay	J	me	J	uly	A	ur.	s	ept.		ct.	N	ĺΟ¥.	I	ec.	Tot	al	٦.
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10,000	12108642001446864200144686420014468642001446864200014468642000144686420001446864	11364612288112571	1 1 3 7 16 27 18 52 64 76 83 99 99	2 3 8 8 12 9 19 22 0 10 8 5 3 1	1 4 9 15 24 30 44 58 81 88 94 97 99 100	59733728 11728 11949 643	3 9 14 22 300 41 59 71 83 86 92 98 100	11 12 20 22 8 18 17 7 13 12 3	2 9 17 31 46 51 63 75 79 88 98 98	2 6 13 27 20 20 20 19 14 10 12 3 4 1	1 5 14 32 58 71 80 87 95 97 90	3 3 7 2 2 1 2 5 0 6 2 1	2 16 35 49 63 94 98 99 100	4 6 25 34 34 34 34 34 34 34 34 34 34 34 34 34	3 7 23 5 5 7 6 8 6 5 9 9 8 100	1 1 5 13 2 2 2 5 2 5 5 1	1 1 5 13 31 52 70 866 969 900 100	4 6 8 12 11 23 21 21 13 10 11 1 2	3 13 21 29 45 59 74 83 99 90 100	2 2 5 7 2 1 7 2 1 7 2 5 6 5 1	1 3 6 17 31 55 60 7 85 90 97 97 99	2 3 5 12 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	147553459720877989999000000000000000000000000000	1 2 6 0 12 15 15 2 13 16 9 2 1 1 1 1 2 1	12 6200 1200 1200 1200 1200 1200 1200 1200	1 5 18 991 116 128 139 197 124 1115 115 209 41 300 16 7 32	149 142 375 452 375 574 776 892 997 1000	14 12 10 2 4 4 2 0 -2 -4 6 -10 -14 -18 -22 -24 -26 -32 -34
18,000		1 3 13 14 17 23 22 19 9 7 3	1 31 21 32 47 62 75 87 93 97 99	5 10 8 13 12 17 21 10 6 4 3 1	4 11 17 26 39 55 67 83 90 94 97 99 100		1 3 7 19 34 40 59 90 92 97 99 100	2 8 14 16 15 20 14 10 5 3 3 2 2	1 7 16 27 455 69 78 95 92 95 97 99 100	1 5 15 24 27 15 17 21 11 1 8 5	1 4 4 300 48 58 700 84 91 97 100	5 127 30 25 21 14 7 21	4 12 31 52 69 93 98 99 100	17 1135 421 120 54	15 13 37 79 87 97 100	3 8 26 26 27 29 26 13 6 1	2 7 25 69 87 95 99 100	8 17 16 32 22 9 6 5 2	68 29 51 84 90 94 99 100	31448844776211	2 9 25 41 60 72 84 89 9 99 100	491 120 181 182 100 101 122 3	3 9 1T 314 57 780 87 95 96 900	5 3 2 2 15 7 18 2 2 16 18 6 7 6 2 2 2	353367223672888379890	4	1 2 7 14 21 30 38 46 68 75 82 82 82 87 99 99 100 100	-20 -24 -24 -26 -30 -32 -36 -36 -42 -44

TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

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38,500	-446 -446 -524 -558 -568 -668 -7	3 10 20 21 20 15 11 13 7 3 4	2 10 26 42 57 69 78 88 93 95 98	48 117 16 17 19 10 115 64 2	39 18 31 43 56 71 79 87 91 95	1231111	1718017718333111	1 8 13 33 54 62 74 89 99 90	1 15 15 16 16 12 10 12 16 15 8	1 2 12 22 34 45 54 61 70 82 93 99	5 6 11 13 13 13 14 13 24 9 6 2	4 8 15 24 35 44 53 63 72 88 94 99	1 5 9 11 16 10 28 19 22 8	1 4 7 14 22 34 42 62 76 93 99 100	2 4 9 18 23 33 25 20 8 2	1 10 23 39 62 79 99	2 9 18 17 41 31 12 8	1 3 9 22 33 62 83 92 97 100	5 5 9 15 18 24 21 20 9 10 2	4 7 14 25 38 55 70 85 91 97	1 7 14 12 17 19 20 8 10 4	1 4 9 18 28 44 56 70 84 89 97 99	2 1 2 6 15 17 19 13 11 7 7 3 1	22 49 23 38 51 66 76 85 91 96 98 99	1 1 7 12 13 18 22 21 13 1 7	12 7 155 38 54 69 79 87 99 100	1 6 27 61 129 199 222 242 274 150 97 61 34 10 2	2 4 14 26 39 54 68 79 88 94 97 99 100	-44 -44 -45 -55 -55 -56 -56 -66 -66 -66
53,00 0	-46 -480 -54 -56 -56 -66 -76 -76 -76 -76 -76 -76 -76 -76 -7	4 20 24 18 17 19	4 25 50 68 86 99	3 6 13 12 22 19 15 2	39 22 35 57 77 92 97	2222	1 9 4 7 5 4 6 4 1	1 8 28 51 72 92 97	4 6 14 20 24 25 16 4	4 9 21 39 60 82 97 100	1 11 29 23 29 18 3	1 2 11 35 55 79 94 97	13 18 21 34 15 10 3	11 27 45 75 88 97 99	5 15 23 24 29 21	4 16 33 52 74 92 100	6 17 23 24 26 22 7	5 18 37 56 76 94 99	3 7 16 27 26 21 13 5	3 10 23 46 67 64 95 99	1 1 4 10 20 28 28 18 11	2 5 13 29 51 74 88 97	1 2 11 21 23 17 13 13	1 4 14 34 56 72 85 97 100	2 5 11 14 30 20 21 11 2 3	2 6 15 26 51 68 85 94 98 99	4 14 44 144 239 269 288 211 116 49 10	15 15 32 51 72 87 99 100	-468 -524 -554 -556 -566 -662 -77
67,500	-48 -52 -54 -56 -56 -62 -66	1 2 7 14 10 4	3 8 26 62 87 97	3 2 5 8 2 6 10 8 3	6 10 20 36 40 52 72 88 94	1 2 2 1	7 1 3 2 4 1	22 49 79 95 00	5 18 22- 13 7 2	8 34 67 87 97	1 5 27 25 11 4 2	8 44 77 92 97	1 1 9 33 33 2	1 3 14 56 98 100		2 7 40 74 96 100	9 29 30 21 6	10 40 72 94 100	3 4 16 26 22 6	9 30 64 92 100	1 5 16 25 28 9	1 2 8 27 57 89 100	1 12 23 10 8 2	2 4 25 65 83 97 100	2 4 13 18 14 7 2	3 16 33 57 75 87 99	9 25 97 202 224 163 96 44 7	15 38 64 83 94 99 99	~50 ~50 ~54 ~56 ~58 ~64 ~64
78,500	-448 -448 -480 -524 -536 -560 -666	1 4 6 5	6 12 35 71 100	3 2 1 2 2	30 50 60 80		2 6 4 2 1 1	11 42 63 84 95 00	1 6 3 4	7 50 71 100	1 5 13 14 6 2 1	2 5 16 47 79 93 98 100	2 4 6 14 19 4	4 12 25 53 92 100	1 4 21 21 11	2 9 45 81 100	1 18 24 15 4	2 31 69 94 100	2 5 19 10 12 2	14 52 72 96 100	106	3 7 27 47 80 100	2 6 4 6 1 1	16 47 68 90 95	1 3 4 6 3 4	17 35 61 74 91	3 10 50 72 89 52 43 39 23 7	16 34 57 70 81 97 99 100	-44 -46 -52 -52 -54 -56 -62 -62 -64
87,000	-44 -44 -46 -50 -56 -56 -60 -60	3 2	60 100	2	100		2	67	3	75 100	1 3 1 1 1	13 50 63 75 88 100	11357521	4 8 20 40 68 88 96 100	8 9 8 2 1	29 61 89 96 100	3 5 13 2 1	13 33 88 96 100	13943	5 20 65 85 100	1 3 2 3 2	8 33 50 75 92 100	1 1 1 1 1 1	40 60 80	2	67 100	1 15 21 35 22 11 12 5 8 6	1 12 27 55 68 76 85 89 94	-40 -42 -44 -48 -50 -52 -54 -58 -60 -62

TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

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10,000	20 18 16 14 12 10 8 6 4 2 0 -2 -4 -8 -10 -12 -14	3	2 8 24 49 661 89 92 94 97 99	23 19 33 26 20 11 5 9 4 6 1	1 4 17 41 60 74 86 92 95 99	249 129 35 16 447 1	1 10 29 51 74 84 90 92 95 99	4 26 41 25 26 21 5 1	3 20 47 64 81 95 99	3 6 22 25 41 8 19 9 7 1 3 1	2 620 36 63 74 87 92 97 97 99	1 6 25 42 41 25 7 2 1	1 5 21 49 77 93 98 99 100	4 47 59 22 8	3 12 42 80 94 99 100	9 36 65 38 6	6 29 71 96 100	4 18 53 53 14 7	3 15 50 86 95 100	4 32 60 37 13 5 2 1	3 23 62 86 95 98 99 100	9 30 49 25 14 8 10 3 1	26 59 75 85 90 97 99 99	4 142 247 140 7 4 5 1 2	32 26 41 65 74 77 97 97 99 100	1 10 559 244 199 182 175 203 194 169 87 67 251 23 10 4	1 4 12 25 346 57 78 87 92 97 98 99 100 100	20 18 16 14 12 10 8 4 2 0 -2 -4 -8 -10 -12 -14
18,000	-2 -4 -8 -10 -12 -14 -16 -18 -22 -24 -26 -28 -30 -32	1	3 15 33 56 72 83 91 95 98 99	3 20 28 37 20 9 7 7 3	2 17 37 64 79 85 92 97 99	10 18 41 42 20 10 3 2	1 7 19 47 75 88 95 97 98 100	17 48 41 25 10 5	1 12 45 72 89 96 99 100	1 8 23 31 51 21 13 3	1 6 21 41 74 89 98 99 99	1 22 45 55 15 7	1 3 18 48 85 95 100	5 50 78 17	3 37 89 100	3 55 74 20 1	2 38 86 99 100	4 29 65 33 13 3	3 22 67 89 98 100	6 22 44 48 29 2	4 18 47 78 97 98 100	1 21 39 44 25 6 5 2	1 15 41 71 87 95 98 99	26 24 26 27 26 21 3 21 1	1 5 21 37 56 73 86 95 97 98 99 99	1 15 163 295 226 271 271 223 174 98 55 23 14 11 4 2	10 26 39 51 66 79 88 97 98 100 100 100	-2 -4 -8 -10 -12 -14 -16 -20 -22 -24 -26 -30 -32 -36
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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

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53,000	-56 -66 -66 -61 -76 -77 -77	10 1 10 1 10 1 10 1 10 1 10 1 10 1 10 1	1 2 8 14 27 43 74 86 95 97	12 14 16 17 10 12	12 24 38 55 72 82	1 2 8 14 20 24 15 9	1 3 12 27	2 12 24 29 20 14	2 13 36 63 82 95 100	2 6 16 25 27 15 24 4 9	2 6 18 37 58 69 87 90 97	3 12 18 24 31 26 7	3 12 27 47 72 93 99	1 13 22 36 24 12 5	1 2 13 32 64 84 95 99	4 35 44 30 6	3 33 70 95 100	1 5 24 27 44 16 5	2 6 25 47 83 96	1 2 7 10 37 34 21 11 7	1 2 8 15 44 70 86 95 100	2 2 4 20 23 20 30 10 7 2	2 3 7 23 43 59 84 93 98	4 11 12 19 27 22 16 5	3 12 22 38 60 78 91 95 99	2 10 22 68 105 167 193 278 262 183 71 23 2	27	-56 -58 -60 -62 -64 -68 -70 -72 -74 -78
67,500	-50 -50 -60 -60 -60 -60 -70 -70	5 1 0 3 2 2 4 14 6 10 6 1 7 3	3 10 15 50 75 90 93	1000	12 28 44 62 82	2 9 5 9 11 4 4 2	4 23 33 52 75 83 92 96 98	2 5 25 18 14 5	3 10 46 71 91 99	1 14 22 30 19 5 1	1 16 40 73 94 99 100	5 39 26 7	10 59 91 100	1 39 35 30 7 1	1 2 13 55 91 99 100	8 43 32 9	9 55 90 100	4 34 47 12 1	4 39 87 99 100	3 17 32 26 21	3 20	1 16 25 24 22 1	1 19 46 73 97 99	2 4 11 20 29 14 3	2 7 20 44 78 97 100	1 3 54 213 265 162 129 71 21 5	75	-50 -54 -58 -60 -62 -64 -64 -70 -72
78,500	-46 -56 -56 -56 -66	1 1 1 2 5	9 18 55 100	22 6 4 1	13 27 67	6 5	39	\$ 10 2	17 50 92 100	1 6 21 16 5 3	2 14 54 85 94 100	1 7 13 14 1	3 22 58 97 100	3 10 25 10 5	25 72 91 100	7 23 16 2	15 63 96 100	5 21 35 7 1	7 38 88 99 100	1 11 23 24 10 1	1 17 50 84 99 100	1 5 9 13 17 6 3	2 11 27 50 80 91 96	7 8 6 10 4 1	19 42 58 86 97	1 4 39 124 144 83 52 25 13	34 64 81 92 97	-46 -48 -50 -52 -54 -56 -62 -64
87,000	-46 -46 -50 -54 -56 -56	1	100	2 2 2 2	33 67 100	1 2 2 1	17 50 83 100	1 2 1 2 2	13 38 50 75 100	2 2 3 5 4	13 25 44 75 100	1 4 7 4	31 75 100	2 6 2 1	18 73 91 100	1 4 10 5	25 75 100	6 10 5 1	27 73 96 100	2 5 10 7	8 28 68 96 100	1 1 5 4 1	15 23 62 92	1 2 2 3 1	11 33 56 89 100	4 10 30 40 32 18 12 4	55 74 88 95	-44 -46 -50 -52 -54 -56 -60
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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

1.71	. 7	J	an.	T:	Feb.	м	arch	77	hpril	17	May	Τ.	June	Τ.	July	Τ.	Aug.	1	Bept.	1	Oct.	Т	VOY.	1 1	Dec.	To	bal	F
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10,000	14 12 10 8 6 4 20 20 -4 -10 -11 -12 -12 -22 -22 -22 -22 -22 -23	5 8 22 19 25 18 23 15 9	3 9 23 36 64 89 95 97	3 9 15 16 8 21 17 13 4 7 2 1 2	2 9 20 31 37 53 66 79 88 91 96 98	1 2 5 1 5 2 4 8 2 1 2 0 1 1 9 7 5 3	1 2 5 15 31 50 64 77 64 90 95 100	4 16 23 28 23 22 12 9 6 4	29 48 64 78 87 93	1 5 30 40 34 17 17 2 5	1 4 24 50 72 84 95 99 100	2 11 40 39 18 5 3	1 9 37 63 81 94 98 100	211 635 157 57	1 9 50 86 97 100	8 38 59 37 7	5 31 71 95 100	10 28 43 36 19 31	1 28 58 84 97 99 100	17729 271339 2461	1 55 25 38 60 80 95 99 100	13 13 18 20 33 24 15 64 24 1	1 3 12 24 38 61 78 88 92 97 97 99	3 6 20 25 29 31 15 9 5 4 2 1	2 69 34 55 76 89 95 98 99 100	11 61 163 188 166 142 140 131 164 131 107 80 59 52 30 21 6 4	1 4 13 24 33 41 49 57 80 86 90 94 98 99 100 100 100	14 12 10 8 6 4 2 0 2 -4 -8 -10 -11 -11 -12 -22 -24 -22 -24
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	-42 -44 -46 -48	14 22 18 16	3 5 8 14 28 38 38 566 77 92 99 00	22355 212233 11662	2 3 5 9 13 29 46 71 824 99 100	2 4 8 8 2 3 7 9 2 6 7 4	1 4 10 29 55 75 92 97	1 7 9 22 25 31 22 15 12 3	1 5 12 27 44 65 90 98 100	7 13 17 28 14 16 16 2	5 14 26 47 66 76 87 95 100	2 1 10 24 38 27 15 14 2 3 2 1	1 97 27 54 73 84 94 98 99 100	1 11 30 47 40 14 1	189 618 99 100	2 11 33 40 40 11 2	1 9 33 62 91 99 100	1 5 11 28 47 26 11 7 1	1	1 3 13 25 22 24 26 20 10	1 3 129 44 61 79 92 99	47 15 19 11 25 18 11 8	73 86 94			1 29 84 159 153 143 140 189 151 139 91 51 21	2 7 16 28 37 45 54 54 62 73 82 90	-48 -50 -52

TABLE I.- SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

Alt.,	t,	J	An.]	eb.	Ma	rch	A	pril	M	ity	J	wne	J	uly	A	ug.	8	ept.	0	et.	N	lov.	1	Dec.	Tot	al	· ·
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58,000	-54 -56 -58 -60 -62 -64 -68 -70 -72 -74 -76 -78	11 10 17 15	1 3 8 13 27 39 61 80 91 98 99	2 4 11 10 12 9 12 8 4	8 23 37 53 66 82 93	1 2 2 17 24 15 15 7 2	1 2 5 7 27 55 72 90 98 100	1 2 6 18 23 19 14 13 3 2	1 3 9 27 50 68 82 95 98	5 6 18 26 35 17 9 5	4 9 24 46 74 88 96	1 2 3 12 17 20 32 9 10	1 3 6 17 33 51 81 90 99	8 38 28 18 15 7	7 40 64 80 93 99	7 19 31 33 21 6 2	6 22 48 76 93 98 100	3 6 27 23 25 13	3 9 37 60 86 99	4 3 7 26 10 22 9 15 3	4 7 14 40 50 72 81 96 99	2 1 1 4 10 18 17 14 15 8	2 3 4 18 36 54 68 83 91	1 3 9 15 17 16 15 10 3 1	1 4 30 48 66 82 93 96 97 98	2 5 13 31 82 129 185 214 227 144 109 42 6	1 2 4 11 22 38 56 75 87 99 100	-54 -58 -62 -64 -66 -70 -72 -74 -78 -80
67,500	-48 -50 -52 -54 -56 -58 -62 -64 -68 -70	2 9 4 12 4 14 2	6 25 33 57 65 94 98	1 7 6 9 4 5 3		1 1 8 10 12 11 11 3 4	2 3 16 33 53 71 89 93 100	5 8 20 25 10 6 2	7 17 43 76 90 97	4 17 35 24 14 4 2	21 55 80 94 98 100	2 8 23 39 20 1	2 11 36 77 99 100	1 3 17 48 29 3	1 4 21 68 97 100	1 22 50 25 6	1 4 24 70 94 99	1 2 15 27 25 12 2	1 21 54 83 98 100	1 9 25 34 14	1 12 42 82 99 100	1 4 9 22 17 11 5 4	1 7 19 49 72 87 93 99	2 16 12 17 11 8 4	3 25 42 66 82 93 99	1 1 6 35 154 299 246 106 55 23 10	1 5 21 53 79 91 96 99 100	-480 -554 -558 -560 -644 -680
78,500	744 -46 -48 -52 -52 -54 -56 -66	2 5 6 10 5	9 25 44 75 91 97	1 1 1 1 1 1	88 92 96	3 6 13 18 5 1	7 20 48 87 98 100	3 2 11 21 14 3 1	6 9 29 67 93 98 100	5 9 19 31 8 1	7 19 45 87 97 99	2 10 25 27 10 1	3 16 49 85 99 100	2 9 25 36 9	3 14 44 89 100	1 10 33 34 15 1	1 2 12 46 81 97 98 100	5 13 31 20 7	7 24 65 91 100	2 6 25 23 15 3	3 11 43 74 93 97 100	6 4 20 17 10 5	10 16 48 75 91 98 100	2 3 9 13 6 4	10 27 46 79 85 94 98	3 17 65 154 260 150 66 20 9 2	96 98	-44 -46 -48 -50 -52 -54 -56 -56 -60 -62 -64
87,000	-38 -40 -42 -44 -46 -52 -54 -58		5 10 35 70 95	114411	13 38 63 88	249922	8 23 58 92 96 100	1 5 14 9 2	3 19 65 94 100	1 3 1 14 13 4	3 13 16 93 87 97	2 4 7 17 17 17 1	4 11 25 57 89 98 100	19 16 3	10 53 93 100	3 10 19 22 10 1	5 19 48 81 96 97 99	3 11 23 17 8 2	5 22 58 84 97 100	1 6 16 21 14 4	2 11 37 71 94 100	1 2 4 11 10 8 4 2	2 22 47 69 87 96	4 5 6 14 3 1 1	11 24 40 76 84 92 95 97	2 7 16 38 117 149 100 47 19 5 2	88	-38 -40 -44 -44 -48 -50 -54 -54 -58
102,000	-30 -32 -34 -36 -42 -44 -46 -48 -50	1	17 53 67 83 100	1	50 83 100		13 25 38 75 88	1 2 4 1	13 38 88 100	1 2 2 1	33 44 67 89 100	1 1 3 2 1 1	10 20 30 60 80 90	2.14431	25 33 67 92 100	1	20 40 50 60 80 90		18 35 71 88 100	1 1 3 3	13 25 63 100		17 33 67 100	1 2 1	20 40 80 100	1 3 1 4 10 10 20 21 20 9	18 28 47	-30 -32 -34 -36 -38 -40 -44 -46 -48
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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Continued

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10,000	108 64 20 -46 -102 -116 -129 -129 -226	4 22 14 21 22 18 13 1	3 6 21 31 44 59 75 88 97 99 100	1 2 7 15 12 14 17 24 10 16 12 5	1 2 7 18 27 38 50 68 75 87 99	2 1 3 10 11 25 27 14 14 6 5 11	2 5 12 21 39 60 71 81 86 89 98	1 8 13 21 20 28 16 13 6 5	1 4 10 19 35 49 70 82 91 98 99	1 5 9 15 34 32 21 11 16 5 4	1 4 10 20 42 62 76 83 94 97 99	1 8 12 36 24 23 14 12 6 2	1 77 15 41 59 75 86 94 99	2 7 11 32 37 28 17	2 7 14 35 59 78 89 97 100	5 22 23 30 35 18 15 3	3 18 33 52 75 87 99 100	1 2 12 17 38 20 19 11 14 9 4 1	1 2 10 22 47 61 74 81 97 97	2 15 26 25 17 15 19 17 6 3	I 11 29 45 57 67 91 95 97 100	9 21 16 19 20 20 14 12 11 4	5 20 31 44 57 71 80 88 95 98	1 8 14 26 20 20 14 14 2 3	1 3 8 17 34 55 78 87 96 97 99	3 15 57 107 193 193 191 176 130 109 74 46 33 10	11 22 33 44 56 677 784 995 997 1000	8 6 4
18,000	-8 -10 -12 -14 -16 -18 -20 -24 -26 -26 -30 -32 -34 -36 -40 -42	1 4 10 25 26 16 20 19 12 4 3	1 41 247 58 72 85 94 97 100	3 1 11 18 17 10 18 15 13 13 1	2 3 11 25 37 45 70 81 91 97 100	1 6 11 18 27 24 12 .60 4 4	1 6 14 28 49 68 77 82 90 93 96 99	2 3 14 20 23 26 23 10 7 5	2 4 14 29 47 66 84 91 98	2 12 12 29 39 20 19 3 5 4	1 9 17 36 61 74 86 92 94 97 100	1 5 16 29 31 13 13 6 12 1	1 5 17 39 63 76 86 92 97 98 99	31 21 36 21 15 17 2	2 16 46 70 83 93 99 100	1 6 11 44 22 36 20 7 4 2	1 5 12 41 55 78 92 96 99 100	1 26 26 24 29 14 15 5 9 2	1 2 13 30 47 66 76 89 93 99 100	13 24 31 25 16 13 9 25 11	1 9 25 463 732 88 94 95 99 100	5 17 17 21 26 10 8 7 6 4 1	3 15 26 40 58 75 82 92 96 99 100	1 6 17 23 31 20 12 15 11 13 4	1 5 16 30 50 63 71 81 88 96 99	3 11 54 146 155 180 187 198 185 123 77 66 30 17	1 4 12 21 32 43 545 65 76 88 93 97 99 100 100	-8 -10 -12 -14 -16 -22 -24 -28 -30 -32 -34 -38 -40 -42
30,000	-34 -36 -36 -42 -44 -46 -52 -54 -58 -62	1 5 20 17 27 27 15 1	1 5 22 36 58 81 93 99 100	1 7 17 13 19 37 13 5	1 7 22 34 50 83 95 99	1 7 18 34 31 20 9 2 1	1 7 21 49 74 90 98 99	1 3 12 26 35 26 15	1 3 14 36 65 87 100	2 10 20 30 55 22 11 2	1 8 21 41 77 91 99 100	1 3 14 28 38 19 10 8	1 3 15 38 69 85 100	1 11 20 57 28 18 9 51	1 1 9 22 60 78 90 96 100	1 9 23 31 28 29 22 6 2	1 7 22 42 61 80 95 100	3 17 29 29 29 17 11 4	2 14 34 54 74 86 94 97 100	5 17 21 37 33 22 12 3	3 15 29 53 75 90 98 100	2 6 16 23 33 36 21 8	1 7 18 39 56 80 95 100	3 2 2 3 3 4 2 1 7 8 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	2 3 18 40 66 80 91 96 98 100	1 24 68 152 157 194 206 256 225 163 126 45 17 6	2 6 15 25 36 49 65 78 88 96 99 100	-34 -38 -40 -44 -48 -55 -55 -55 -62
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TABLE 1.- SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER AIR TEMPERATURES - Continued

88,500 -22	Total	e. T	Dec.	Nov.	1	ct.	C	ept.	S	lug.		uly	_ j	ane	J	lay	h	April	arch	M	eb.	F	an.	J	t,	Alt.,
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78,500 -44 -48 -50 -52 -534 -50 -52 -534 -50 -50 -50 -50 -50 -60 -60 -60 -60 -60 -60 -60 -60 -60 -6	1 1 29 4 20 20 20 20 20 20 20 20 20 20 20 20 20	2	3 4 7 12 7 20 10 31 24 56 22 82 9 92 3 96 1 97	6 26 60 78 94 100	5 18 29 16 14 5	7.3	3 5 12 20 17 11 2	1 3 11 18 36 68 89 99	1 7 6 17 27 18 9	2	1 8 32 24 24 12 4 2 1	16 35 65 85 93	20 30 21 8	5 22 50 85 98 100	5 16 26 34 12 2	3 21 48 76 94 99	i	2 3 11 17 15 37 20 63 22 92 6 100	24 62 80 94	10 19 9 7	10 25 50 65 80 95		22 31 53 67 83	5 3 8 5 6 4	~50 ~52 ~54 ~56 ~60 ~64 ~66 ~70 ~72	53,000
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TABLE I. - SUMMARY OF RADIOSONDE MEASUREMENTS OF UPPER-AIR TEMPERATURES - Concluded

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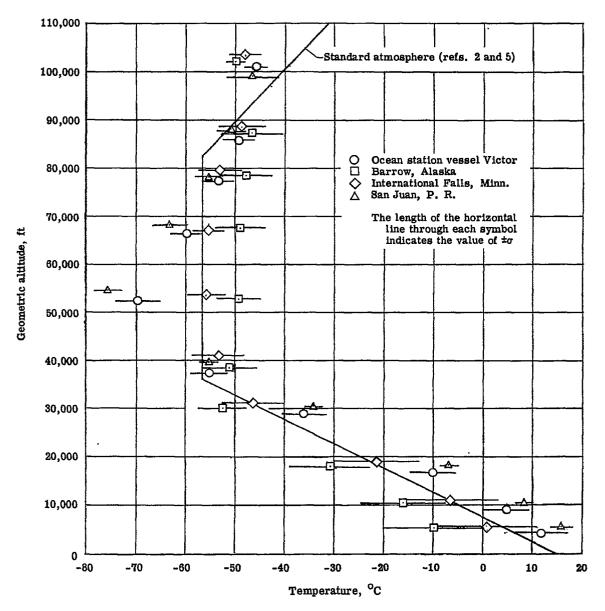


Figure 1.- Comparison of upper-air temperature measurements for several geographic locations with temperatures for standard atmosphere.